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The Examination of the Aluminum Alloy 7017 as a Replacement for the Aluminum Alloy 7039 in Lightweight Armor Systems

by Tyrone L Jones and Brian E Placzankis

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Weapons and Materials Research Directorate (ARL)

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14. ABSTRACT <p>The aluminum alloy (AA) 7039 has been recognized as a serviceable armor plate alloy for years. However, the inherent stress corrosion cracking susceptibility of AA7039 has led to a need for a replacement. AA7017 (aluminum-zinc-magnesium) was created as a slightly stronger and more corrosion-resistant version of AA7039 for use in ground vehicle applications. Ballistic impact experiments evaluated the plate's ability to resist penetration under high-strain-rate loading. These experiments provide a gauge of penetration resistance for aluminum used in ground vehicle applications. This report focused on the dynamic investigation of 12.7- through 101.6-mm (0.5- through 4.0-inch)-thick plates, assessment of the penetration resistance, and the selection of a penetrative baseline for potential future 7000 series aluminum alloys.</p>					
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Contents

List of Figures	iv
List of Tables	iv
Acknowledgments	v
1. Introduction	1
2. Experimental Procedures	2
3. Armor Piercing and Fragment-Simulating Projectiles	3
4. Results and Analysis	5
5. Conclusion	11
6. References	12
Appendix. Raw Data	13
List of Symbols, Abbreviations, and Acronyms	65
Distribution List	67

List of Figures

Fig. 1	Typical test setup.....	3
Fig. 2	AP projectiles	4
Fig. 3	FSP projectiles	5
Fig. 4	Ballistic penetration resistance of 0.30-cal. APM2 vs. AA7017 at 30°	8
Fig. 5	Ballistic penetration resistance of 0.30-cal. APM2 vs. AA7017 at 0° ...	8
Fig. 6	Ballistic penetration resistance of 0.50-cal. APM2 vs. AA7017 plate at 0°	9
Fig. 7	Ballistic penetration resistance of 14.5-mm BS41 vs. AA7017 plate at 0°	9
Fig. 8	Ballistic penetration resistance of 0.50-cal. FSP vs. AA7017 plate at 0°	10
Fig. 9	Ballistic penetration resistance of 20-mm FSP vs. AA7017 plate at 0°	10

List of Tables

Table 1	Chemical composition, weight percent.....	1
Table 2	Minimum mechanical properties	2
Table 3	AP projectiles' physical characteristics.....	4
Table 4	The 0.30-cal. APM2, 30° obliquity V_{50} ballistic limits for AA7017	5
Table 5	The 0.30-cal. APM2, 0° obliquity V_{50} ballistic limits for AA7017	6
Table 6	The 0.50-cal. APM2, 0° obliquity V_{50} ballistic limits for AA7017	6
Table 7	The 14-mm BS41, 0° obliquity V_{50} ballistic limits for AA7017	6
Table 8	The 0.50-cal. FSP, 0° obliquity V_{50} ballistic limits for AA7017	7
Table 9	The 20-mm FSP, 0° obliquity V_{50} ballistic limits for AA7017	7

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1. Introduction

The use of aluminum alloys that demonstrate a combination of high strength, weldability, and corrosion resistance for vehicle structural applications has always been of interest to the Department of Defense. While aluminum alloy (AA) 7039 has been recognized as a weldable armor plate alloy for many years,¹ the inherent stress corrosion cracking susceptibility of AA7039² has led to a need for a replacement. Alcan Inc. addressed this issue further with a slightly stronger and more corrosion-resistant AA7017.³

This alloy has been successfully fielded on British and German armored ground systems and therefore became the basis for a fiscal year 2012 Office of the Deputy Assistant Secretary of Defense funded Foreign Comparative Test program to validate and ultimately transition AA7017 for availability in US acquisition. AA7017 (aluminum-zinc-magnesium) has demonstrated an excellent combination of mechanical properties, both quasi-static and at high strain rates.⁴ The AA7039 and AA7017 chemical composition limits and mechanical property minimums^{1,4} are listed in Tables 1 and 2, respectively. The enhanced properties make AA7017 a potential replacement for AA7039 and an aluminum alloy of interest for ground vehicle structural application. The ultimate goal of this study was to establish dynamic penetration performance for AA7017 when used in ballistic applications.

Table 1 Chemical composition, weight percent

Elements	Symbol	7017 alloy	7039 alloy
Silicon	Si	0.35	0.30
Iron	Fe	0.45	0.40
Copper	Cu	0.20	0.10
Manganese	Mn	0.05–0.50	0.10–0.40
Magnesium	Mg	2.0–3.0	2.3–3.3
Chromium	Cr	0.35	0.15–0.25
Nickel	Ni	0.10	N/A
Zinc	Zn	4.0–5.2	3.5–4.5
Titanium	Ti	0.15	0.10
Zirconium	Zr	0.10–0.25	Not applicable
Other, min	(Mn + Cr)	0.15	Not applicable
Other, max. Each	. . .	0.05	0.05
Other, max. Total	. .	0.15	0.15
Aluminum	Al	Remainder	Remainder

Note: Where single units are shown (except for Mn + Cr), these indicate the maximum amounts permitted.

Table 2 Minimum mechanical properties

Thickness (mm)	Tensile strength (MPa)		Yield strength, 0.2% offset (MPa)		Elongation (%)	
	7017	7039	7017	7039	7017	7039
12.7–38.1, including	434	414	365	352	9	9
38.125–101.6, including	414	393	345	331	8	8

All experiments of AA7017 were conducted in accordance with V₅₀ Ballistic Test for Armor (MIL-STD-662F).⁵ This test methodology has been used for years to determine penetration resistance for aluminum alloys in ground vehicle applications.

2. Experimental Procedures

The V₅₀ is defined as the impact velocity at which the projectile is equally as likely to penetrate the target as it is to arrest. A 0.51-mm (0.020-inch) 2024 T3 aluminum witness plate is positioned 152 mm (6 inches) behind the target to determine the outcome of each shot. An impact is regarded as a complete penetration (CP), or loss, if the projectile or a resulting target fragment from impact creates a hole in the witness plate through which light can be observed. If an impact does not result in a CP, it is considered a partial penetration (PP), or win. To keep results as consistent as possible, only shots conforming to the following conditions were used to determine the V₅₀: The projectile must be unyawed; less than 2° of total yaw for armor-piercing (AP) rounds and less than 5° of total yaw for fragment-simulating projectiles (FSPs); and strike the target at least 2 projectile diameters from any previous impact or damage or the edge of the target. Total yaw is defined as the vector sum of the projectile's pitch and yaw and is listed as "Gamma" in the raw data in the Appendix. The V₅₀ is calculated by the arithmetic mean of an equal number of CPs and PPs within an 18-m/s (60 ft/s)-spread for a 2 + 2 V₅₀; a 27-m/s (90 ft/s)-spread for a 3 + 3 V₅₀; and as small of a spread as attainable for a 5 + 5 V₅₀.⁵

Projectile velocities for the determination of the V₅₀ were measured using 1 of 2 methods as shown in Fig. 1. The first method is an orthogonal flash X-ray system as described in detail by Grabarek and Herr,⁶ which also measures pitch and yaw. The second method uses 3 infrared (IR) break screens and a chronograph. The velocity is calculated using the first and third screens with the middle screen used to check for bad readings. The flash X-ray method was used in situations with

projectiles that historically exhibit excessive yaw or if space did not allow for the use of the IR break screens. When the IR break screens and chronograph were used, the projectile velocity was corrected to the target-impact location using a correction factor based on an initial flash X-ray reading at the impact location. The correction was made using Eqs. 1 and 2 in lieu of utilizing air-drag factors.

$$\frac{(\text{X-ray velocity})}{(\text{chronograph velocity})} = (\text{correction factor}). \quad (1)$$

$$(\text{correction factor}) \times (\text{chronograph velocity}) = (\text{corrected velocity}). \quad (2)$$

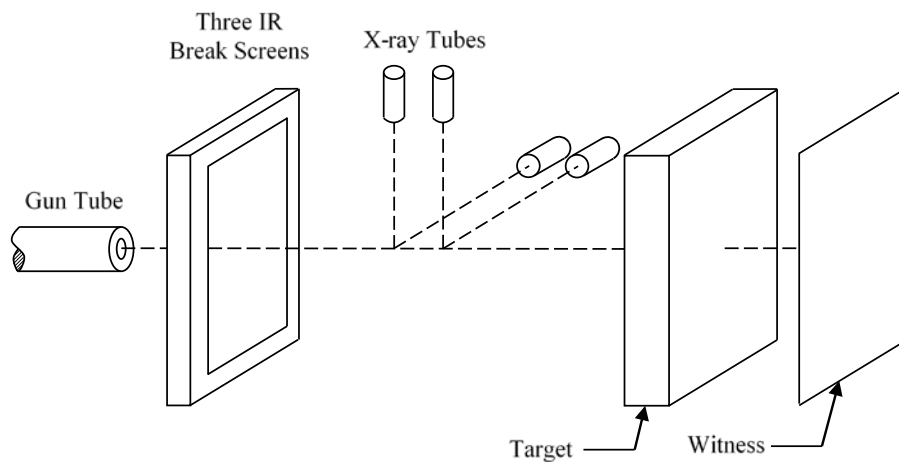


Fig. 1 Typical test setup⁷

3. Armor Piercing and Fragment-Simulating Projectiles

The US 0.30-cal. APM2, 0.50-cal. APM2, and the Soviet 14.5-mm BS41 are the 3 AP projectiles that were used in this study. Cross sections of these projectiles are shown in Fig. 2. The APM2 projectiles have hardened steel cores with hardness of Rockwell C61–66, whereas the BS41 has a tungsten carbide core. The physical characteristics of these projectiles are listed in Table 3. Additionally, a few experiments were repeated with the 0.30-cal. APM2 Test Parts Kit (0.30-cal. kit) round. This round is a US Army-authorized replacement for the historical 0.30-cal. APM2 due to the significant depletion of APM2 supply.

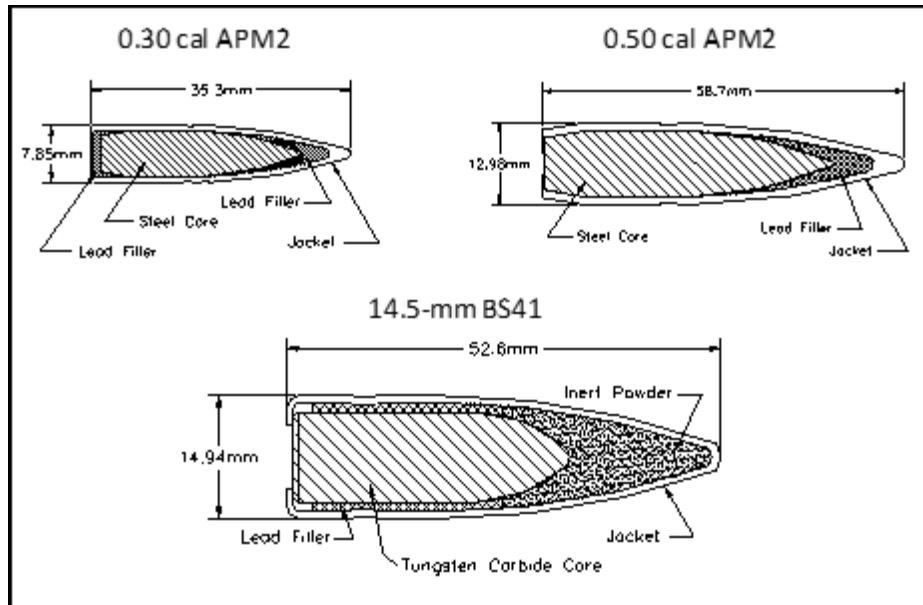


Fig. 2 AP projectiles

Table 3 AP projectiles' physical characteristics⁸

Projectile type	Length (mm)	Projectile diameter (mm)	Weight (g)	Length (mm)	Core diameter (mm)	Weight (g)
0.30-cal. APM2	35.3	7.85	10.8	27.4	6.2	5.3
0.50-cal. APM2	58.7	12.98	45.9	47.5	6.2	25.9
14.5-mm BS41	52.6	14.94	63.2	32.3	10.9	25.9

FSPs (Fig. 3) are a family of projectiles that are flat-nosed, right circular steel cylinders manufactured to MIL-DTL-46593B (MR).⁹ These projectiles are used in material evaluations and acceptance testing to simulate performance against fragments produced from improvised explosive devices and artillery. Both 0.50-cal. and 20-mm FSPs were used for the evaluation of AA7039.

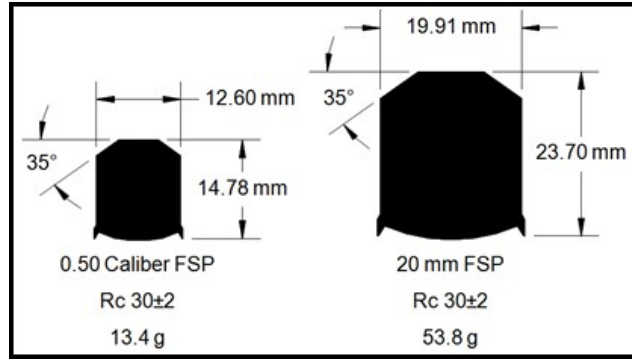


Fig. 3 FSP projectiles⁷

4. Results and Analysis

The results of the AA7017 ballistic evaluation were compared with the required ballistic limit acceptance curve of AA7039 published in MIL-DTL-46063H as a reference point. The experimental matrix for the penetration analysis is shown in Tables 4–9. The individual shot records are provided in the Appendix. Tables 4–9 provide the AA7017 experimental data generated.

Table 4 The 0.30-cal. APM2, 30° obliquity V_{50} ballistic limits for AA7017

Plate identification (ID)	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V_{50} (m/s)	Standard deviation (m/s)
495867-3A1	T6	12.70	12.88	476	6
459867-3A1 ^a	T6	12.70	12.88	477	11
495867-1A2 ^a	T6	12.70	12.88	485	9
495867-1A2	T6	12.70	12.88	490	10
K889 T7651	T7	12.70	13.21	479	10
495871-5G1	T6	19.05	19.33	631	7
495871-1G2	T6	19.05	19.30	641	10
K889 T7651	T7	19.05	19.96	633	10

^a0.30-cal. kit

Table 5 The 0.30-cal. APM2, 0° obliquity V₅₀ ballistic limits for AA7017

Plate ID	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V ₅₀ (m/s)	Standard deviation (m/s)
495871-1G2	T6	19.05	19.30	558	6
495871-5G1	T6	19.05	19.32	564	7
K889	T7	19.05	19.95	569	11
495880-4E2	T6	25.40	25.52	659	10
495880-4E2 ^a	T6	25.40	25.53	653	7
495880-4B1 ^a	T6	25.40	25.48	660	6
495880-4B1	T6	25.40	25.48	650	7
495892-1E1 ^a	T6	38.10	38.40	857	7
495892-1E1	T6	38.10	38.40	833	5
495892-1B2 ^a	T6	38.10	38.31	847	7
495892-1B2	T6	38.10	38.31	833	4
K889	T7	38.10	38.93	827	6

^a0.30-cal kit**Table 6 The 0.50-cal. APM2, 0° obliquity V₅₀ ballistic limits for AA7017**

Plate ID	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V ₅₀ (m/s)	Standard deviation (m/s)
495892-1E1	T6	38.10	38.38	626	6
K889-T7651	T7	38.10	38.91	625	8
495905-2F1	T6	50.80	51.13	727	6
495905-2G2	T6	50.80	51.08	725	5
K889-T7651	T7	50.80	52.39	731	6
495930-2H1	T6	63.50	63.98	839	9
495930-2K1	T6	63.50	63.98	831	8
495935-1D1	T6	76.20	76.66	920	7
495935-1D2	T6	76.20	76.68	931	6
K889-T7651	T7	76.20	74.86	899	5

Table 7 The 14-mm BS41, 0° obliquity V₅₀ ballistic limits for AA7017

Plate ID	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V ₅₀ (m/s)	Standard deviation (m/s)
495935-1D1	T6	76.20	76.65	864	8
495935-1D2	T6	76.20	76.68	859	6
K889-T7651	T7	76.20	74.86	837	5
495953-1E1	T6	88.90	89.47	948	8
495953-1E2	T6	88.90	89.52	941	10
495959-1G1	T6	101.60	102.65	1015 ^a	...
495959-1G2	T6	101.60	102.46	1014 ^a	...
K889-T7651	T7	101.60	99.02	984	5

^aTesting halted; reached max firing velocity of gun; high PP

Table 8 The 0.50-cal. FSP, 0° obliquity V_{50} ballistic limits for AA7017

Plate ID	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V_{50} (m/s)	Standard deviation (m/s)
495871-1G2	T6	19.05	19.29	660	8
495871-5G1	T6	19.05	19.30	625	5
K889-T7651	T7	19.05	19.89	650	8
495880-4E2	T6	25.40	25.50	1049	8
495880-4B1	T6	25.40	25.48	1093	9

Table 9 The 20-mm FSP, 0° obliquity V_{50} ballistic limits for AA7017

Plate ID	Alloy temper	Nominal thickness (mm)	Actual thickness (mm)	V_{50} (m/s)	Standard deviation (m/s)
K889 T7651, 469280A2	T7	19.05	19.95	346	21
495880-4B1	T6	25.40	25.48	462	9
495880-4E2	T6	25.40	25.50	463	5
495892-1E1	T6	38.10	38.38	903	7
495892-1B2	T6	38.10	38.30	877	5
K889 T7651, 46950640	T6	38.10	38.93	903	19
495905-2F1	T6	50.80	51.13	1301	8

Figures 4–9 showed the AA7017 experimental data generated compared with the AA7039 minimum V_{50} s. The AA7017 data displayed are the plots of V_{50} as a function of the plate thickness. A line depicting the $V_{50-2\sigma}$ for AA7017 was plotted for comparison to the AA7039 acceptance requirement from the specification. This line represents a V_{02} (2% probability that the plate will be defeated) rather than a V_{50} (50% probability that the plate will be defeated). To ensure successful protection at a given thickness, the lower band of the 2σ distribution (V_{02} line) is used to define minimum-acceptable performance. An experimental V_{50} falling below this line is considered unacceptable.

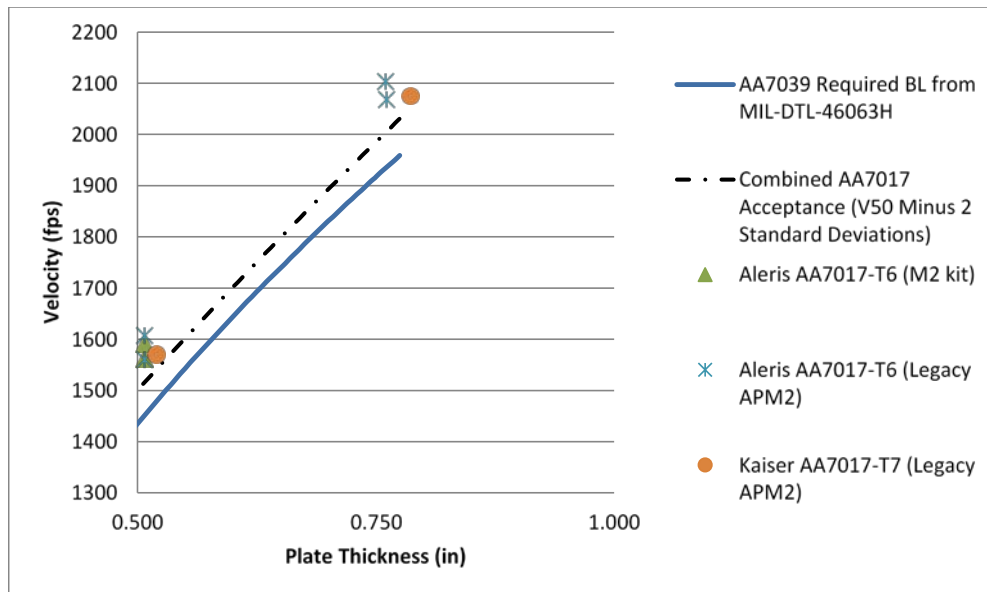


Fig. 4 Ballistic penetration resistance of 0.30-cal. APM2 vs. AA7017 at 30°

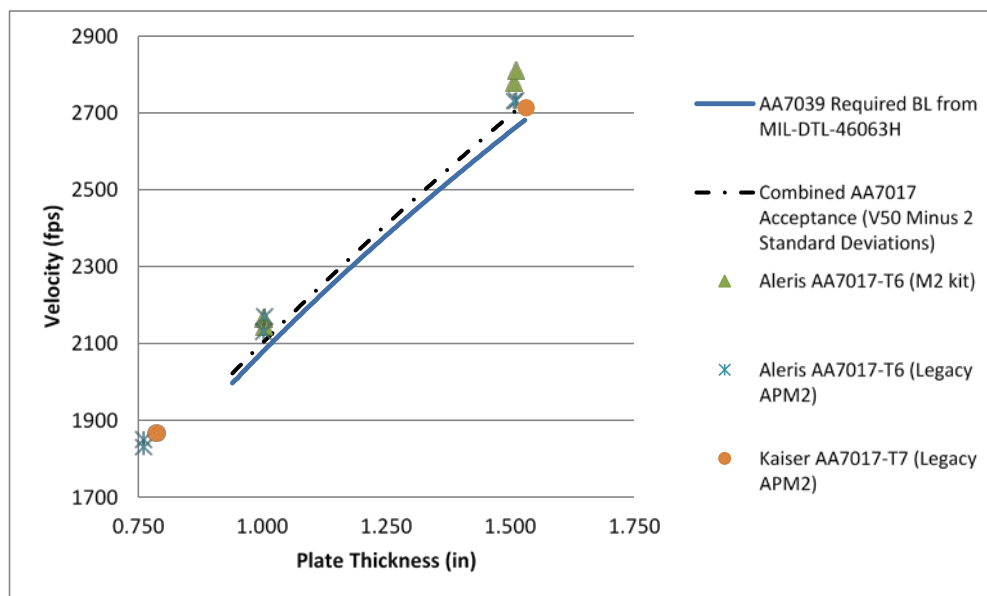


Fig. 5 Ballistic penetration resistance of 0.30-cal. APM2 vs. AA7017 at 0°

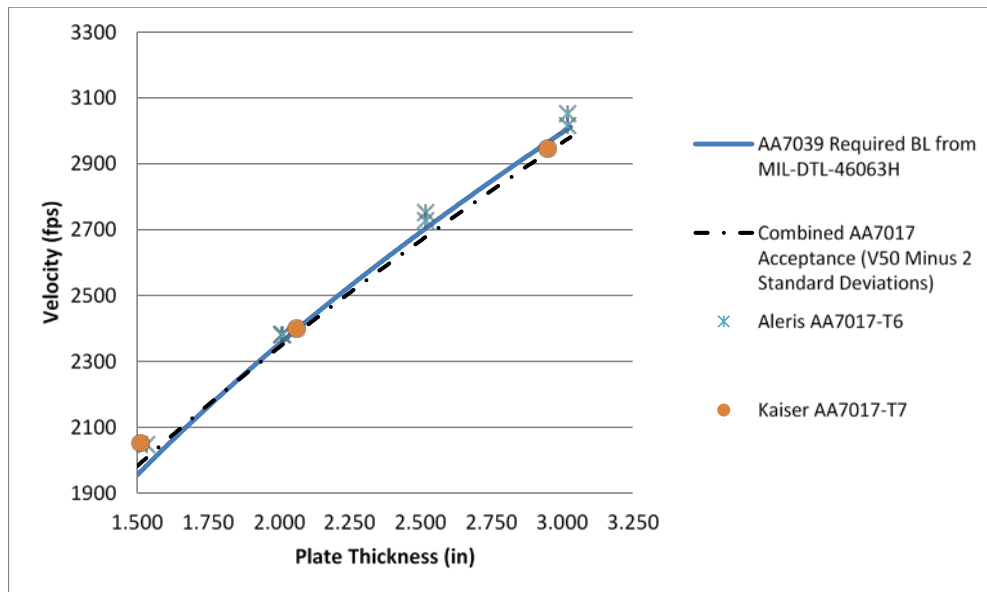


Fig. 6 Ballistic penetration resistance of 0.50-cal. APM2 vs. AA7017 plate at 0°

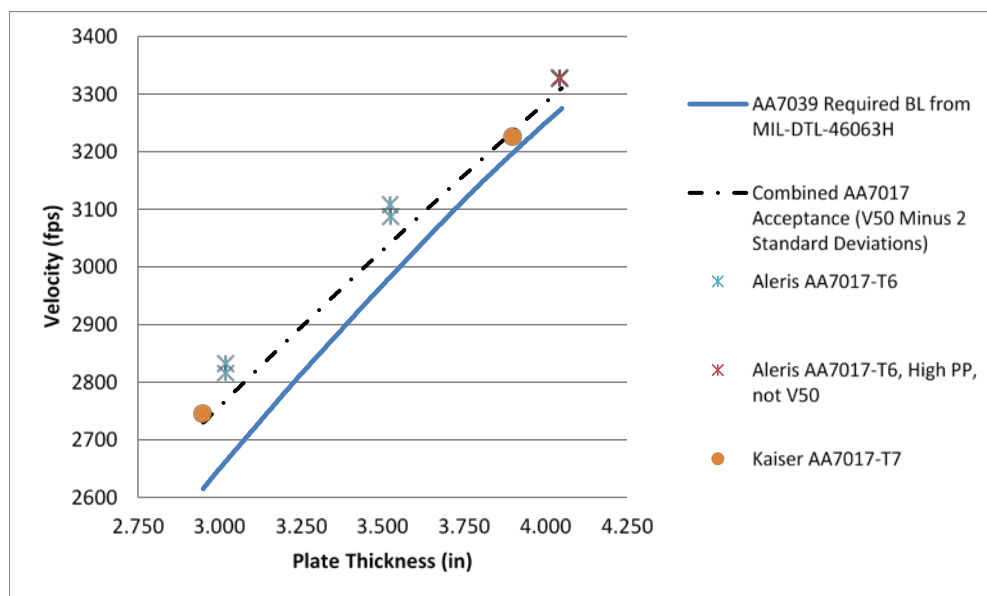


Fig. 7 Ballistic penetration resistance of 14.5-mm BS41 vs. AA7017 plate at 0°

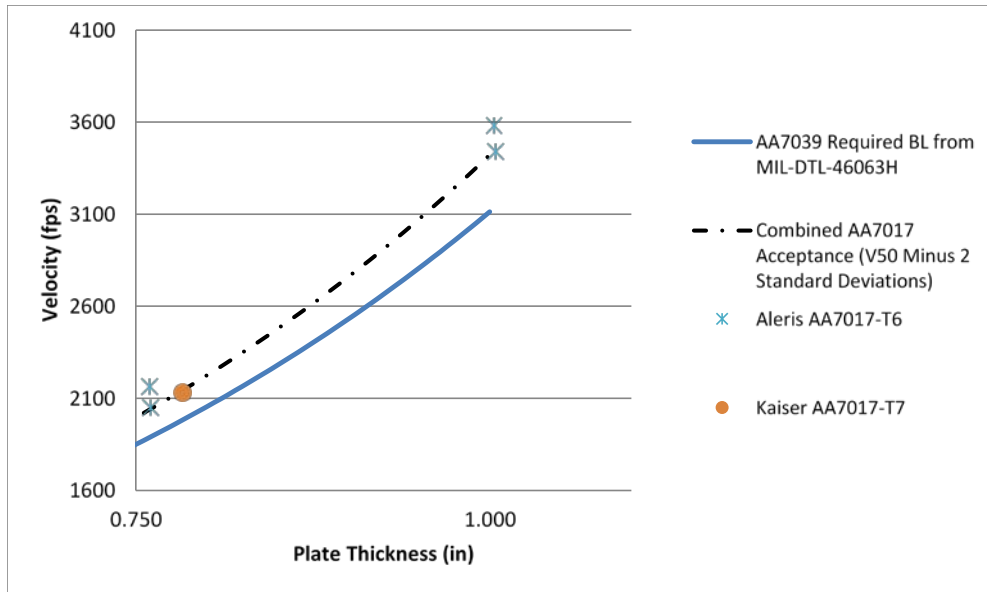


Fig. 8 Ballistic penetration resistance of 0.50-cal. FSP vs. AA7017 plate at 0°

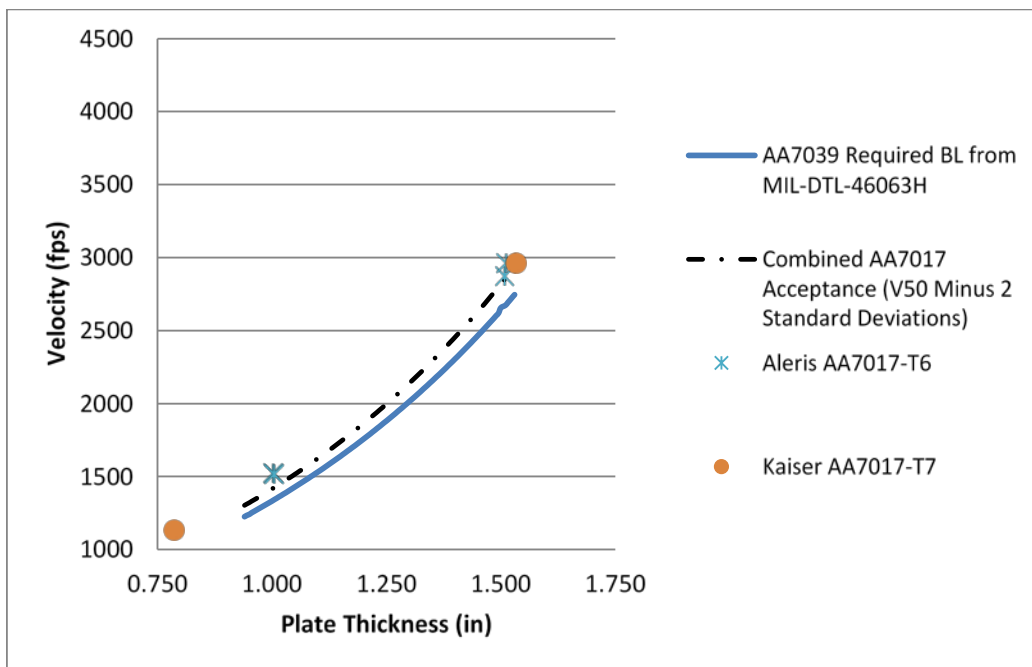


Fig. 9 Ballistic penetration resistance of 20-mm FSP vs. AA7017 plate at 0°

The data collected by the US Army Research Laboratory were then used to generate acceptance tables for MIL-DTL-32505. The acceptance velocities were calculated by fitting the V_{50} data minus 2 standard deviations.

5. Conclusion

A dynamic experimental evaluation was performed on the AA7017 in the T6 and T7 tempers. This report has compared the performance of AA7017 against existing AA7039 military specification, aluminum-armor material. AA7017 outperformed AA7039 against both AP and FSP projectiles. The only exception is 0.50-cal. APM2 performance above 2.000 inches, where AA7039 exhibits a slightly higher performance. This report has also documented the calculations used to derive the acceptance tables included in the new military specification, MIL-DTL-32505. As a result of this research, AA7017 has been recommended as a replacement.

6. References

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Appendix. Raw Data

This appendix appears in its original form, without editorial change.

Approved for public release; distribution is unlimited.

0.30-cal APM2 Legacy

Target:	AA7017-T6		Date:	25-Mar-13					
Plate #:	495867-1A2		Test Site:	EF-106					
Lot#:	1A2								
Avg. Thickness:	0.507 "	12.878 mm							
Hardness:	137 HBN								
Obliquity:	30°								
Projectile:	30cal APM2	Lot #:	TW18035						
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	490 m/s	1607 ft/s							
High PP:	495 m/s	1624 ft/s							
V50:	490 m/s	1608 ft/s				# shots:	6		
Std Dev:	10 m/s	32 ft/s				Spread:	26 m/s	85 ft/s	
ZMR:	5 m/s	16 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
490	1607	--	--	--	PP	Yes	--	12467	
521	1709	--	--	--	CP	No	--	12468	
514	1686	--	--	--	CP	No	--	12469	
516	1692	--	--	--	CP	No	--	12470	
495	1624	--	--	--	CP	Yes	--	12471	
471	1545	--	--	--	PP	Yes	--	12472	
492	1614	--	--	--	CP	Yes	--	12473	
497	1630	--	--	--	CP	Yes	--	12474	
496	1627	--	--	--	PP	Yes	--	12475	

Target:	AA7017-T6			Date:	18-Mar-13						
Plate #:	495867-3A1			Test Site:	EF-106						
Lot#:	3A1										
Avg. Thickness:	0.507 "		12.884 mm								
Hardness:	137 HBN										
Obliquity:	30°										
Projectile:	30cal	APM2	Lot #:	TW18035							
Setup:	AA7017-Air(6")-AA2024(0.020")										
Velocity Measurement:	Chrono										
Low CP:	478 m/s		1568 ft/s								
High PP:	472 m/s		1548 ft/s								
V50:	476 m/s		1560 ft/s			# shots:	6				
Std Dev:	6 m/s		20 ft/s			Spread:	14 m/s		46 ft/s		
ZMR:	0 m/s		0 ft/s								
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot			
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50		#			
445	1460	--	--	--	PP	No	--	12439			
469	1538	--	--	--	PP	Yes	--	12440			
497	1630	--	--	--	CP	No	--	12441			
493	1617	--	--	--	CP	No	--	12442			
449	1473	--	--	--	PP	No	--	12443			
491	1610	--	--	--	CP	No	--	12444			
472	1548	--	--	--	PP	Yes	--	12445			
494	1620	--	--	--	CP	No	--	12446			
483	1584	--	--	--	CP	Yes	--	12447			
478	1568	--	--	--	CP	Yes	--	12448			

Target:	AA7017-T7			Date:	14-Oct-10			
Plate #:	K889 T7651			Test Site:	EF-106			
Lot#:	T7651							
Avg. Thickness:	0.520 "		13.214 mm					
Hardness:	134 HBN							
Obliquity:	30°							
Projectile:	30cal APM2		Lot #:	TW18035				
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	486 m/s		1594 ft/s					
High PP:	471 m/s		1545 ft/s					
V50:	479 m/s		1570 ft/s		# shots:	4		
Std Dev:	10 m/s		31 ft/s		Spread:	18 m/s		59 ft/s
ZMR:	0 m/s		0 ft/s					
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)			
470	1542	--	--	1.12	PP	Yes	--	9931
486	1594	--	--	--	CP	Yes	--	9932
465	1525	--	--	--	PP	No	--	9933
471	1545	--	--	--	PP	Yes	--	9934
488	1601	--	--	--	CP	Yes	--	9935

Target:	AA7017-T6			Date:	26-Mar-13			
Plate #:	495871-5G1			Test Site:	EF-106			
Lot#:	5G1							
Avg. Thickness:	0.761 "		19.317 mm					
Hardness:	137 HBN							
Obliquity:	0°							
Projectile:	30cal APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	566 m/s		1856 ft/s					
High PP:	559 m/s		1834 ft/s					
V50:	564 m/s		1851 ft/s			# shots:	4	
Std Dev:	7 m/s		24 ft/s			Spread:	16 m/s	52 ft/s
ZMR:	0 m/s		0 ft/s					
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
550	1804	--	--	--	PP	No	--	12482
574	1883	--	--	--	CP	Yes	--	12483
558	1830	--	--	--	PP	Yes	--	12484
566	1856	--	--	--	CP	Yes	--	12485
554	1817	--	--	--	PP	No	--	12486
559	1834	--	--	--	PP	Yes	--	12487

Target:	AA7017-T6			Date:	26-Mar-13				
Plate #:	495871-1G2			Test Site:	EF-106				
Lot#:	1G2								
Avg. Thickness:	0.760 "		19.304 mm						
Hardness:	134 HBN								
Obliquity:	0°								
Projectile:	30cal	APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	562 m/s	1843 ft/s							
High PP:	553 m/s	1814 ft/s							
V50:	558 m/s	1830 ft/s				# shots:	4		
Std Dev:	6 m/s	21 ft/s				Spread:	13 m/s	43 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
585	1919	--	--	--	CP	No	--	12476	
533	1748	--	--	--	PP	No	--	12477	
552	1811	--	--	--	PP	Yes	--	12478	
565	1853	--	--	--	CP	Yes	--	12479	
553	1814	--	--	--	PP	Yes	--	12480	
562	1843	--	--	--	CP	Yes	--	12481	

Target:	AA7017-t7			Date:	12-Oct-10				
Plate #:	K889			Test Site:	EF-106				
Lot#:	K889								
Avg. Thickness:	0.786 "		19.952 mm						
Hardness:	128 HBN								
Obliquity:	0°								
Projectile:	30cal APM2	Lot #:	TW18035						
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	576 m/s		1889 ft/s						
High PP:	566 m/s		1856 ft/s						
V50:	569 m/s		1867 ft/s			# shots:	6		
Std Dev:	11 m/s		36 ft/s			Spread:	25 m/s	82 ft/s	
ZMR:	0 m/s		0 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
580	1902	--	--	--	CP	Yes	--	9915	
500	1640	--	--	--	PP	No	--	9916	
547	1794	--	--	--	PP	No	--	9917	
559	1834	--	--	--	PP	Yes	--	9918	
566	1856	--	--	--	PP	Yes	--	9919	
580	1902	--	--	--	CP	Yes	--	9920	
555	1820	--	--	--	PP	Yes	--	9921	
576	1889	--	--	--	CP	Yes	--	9922	

Target:	AA7017-T6			Date:	3-Apr-13				
Plate #:	495871-1G2			Test Site:	EF-106				
Lot#:	1G2								
Avg. Thickness:	0.760 "		19.304 mm						
Hardness:	134 HBN								
Obliquity:	30°								
Projectile:	30cal	APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	634 m/s		2080 ft/s						
High PP:	642 m/s		2106 ft/s						
V50:	641 m/s		2103 ft/s			# shots:	6		
Std Dev:	10 m/s		34 ft/s			Spread:	24 m/s	79 ft/s	
ZMR:	8 m/s		26 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50		#	
626	2053	--	--	--	PP	No	--	12521	
660	2165	--	--	--	CP	No	--	12522	
634	2080	--	--	--	CP	Yes	--	12523	
633	2076	--	--	--	PP	Yes	--	12524	
662	2171	--	--	--	CP	No	--	12525	
642	2106	--	--	--	PP	Yes	--	12526	
631	2070	--	--	--	PP	Yes	--	12527	
655	2148	--	--	--	CP	Yes	--	12528	
652	2139	--	--	--	CP	Yes	--	12529	

Target:	AA7017-T6			Date:	2-Apr-13					
Plate #:	495871-5G1			Test Site:	EF-106					
Lot#:	5G1									
Avg. Thickness	0.761	"	19.329	mm						
Hardness:	137	HBN								
Obliquity:	30°									
Projectile:	30cal	APM2	Lot #:	TW18035						
Setup:	AA7017-Air(6")-AA2024(0.020")									
Velocity Measurement:	Chrono									
Low CP:	634	m/s	2080	ft/s						
High PP:	629	m/s	2063	ft/s						
V50:	631	m/s	2069	ft/s		# shots:	4			
Std Dev:	7	m/s	23	ft/s		Spread:	16	m/s	52	ft/s
ZMR:	0	m/s	0	ft/s						
Striking	Striking	Pitch	Yaw	Gamma	Result	Used	Comments	Shot		
Velocity	Velocity					for V50		#		
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)					
629	2063	--	--	--	PP	Yes	--	12514		
649	2129	--	--	--	CP	No	--	12515		
645	2116	--	--	--	CP	No	--	12516		
622	2040	--	--	--	PP	Yes	--	12517		
646	2119	--	--	--	CP	No	--	12518		
634	2080	--	--	--	CP	Yes	--	12519		
638	2093	--	--	--	CP	Yes	--	12520		

Target:	AA7017-T7			Date:	13-Oct-10			
Plate #:	K889 T7651			Test Site:	EF-106			
Lot#:	T7651							
Avg. Thickness:	0.786	"	19.964	mm				
Hardness:	128	HBN						
Obliquity:	30°							
Projectile:	30cal	APM2	Lot #:	TW18035				
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	639	m/s	2096	ft/s				
High PP:	634	m/s	2080	ft/s				
V50:	633	m/s	2075	ft/s		# shots:	6	
Std Dev:	10	m/s	34	ft/s		Spread:	24	m/s
ZMR:	0	m/s	0	ft/s				79
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50		#
594	1948	--	--	--	PP	No	--	9923
619	2030	--	--	--	PP	Yes	--	9924
660	2165	--	--	--	CP	No	--	9925
639	2096	--	--	--	CP	Yes	--	9926
634	2080	--	--	--	PP	Yes	--	9927
620	2034	--	--	--	PP	Yes	--	9928
643	2109	--	--	--	CP	Yes	--	9929
640	2099	--	--	--	CP	Yes	--	9930

Target:	AA7017-T6			Date:	27-Mar-13			
Plate #:	495880-4E2			Test Site:	EF-106			
Lot#:	4E2							
Avg. Thickness:	1.005 "	25.521	mm					
Hardness:	126 HBN							
Obliquity:	0°							
Projectile:	30cal APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	657 m/s	2155	ft/s					
High PP:	653 m/s	2142	ft/s					
V50:	659 m/s	2160	ft/s		# shots:	6		
Std Dev:	10 m/s	32	ft/s		Spread:	24 m/s	79	ft/s
ZMR:	0 m/s	0	ft/s					
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)			
672	2204	--	--	--	CP	Yes	--	12488
635	2083	--	--	--	PP	No	--	12489
657	2155	--	--	--	CP	Yes	--	12490
648	2125	--	--	--	PP	Yes	--	12491
652	2139	--	--	--	PP	Yes	--	12492
648	2125	--	--	--	PP	No	--	12493
653	2142	--	--	--	PP	Yes	--	12494
681	2234	--	--	--	CP	No	--	12495
669	2194	--	--	--	CP	Yes	--	12496

Target:	AA7017-T6			Date:	2-Apr-13			
Plate #:	495880-4B1			Test Site:	EF-106			
Lot#:	4B1							
Avg. Thickness:	1.003 "		25.476 mm					
Hardness:	131 HBN							
Obliquity:	0°							
Projectile:	30cal	APM2	Lot #:	TW18035				
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	654 m/s		2145 ft/s					
High PP:	656 m/s		2152 ft/s					
V50:	650 m/s		2131 ft/s		# shots:	4		
Std Dev:	7 m/s		22 ft/s		Spread:	15 m/s		49 ft/s
ZMR:	0 m/s		0 ft/s					
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)			
654	2145	--	--	--	CP	Yes	--	12510
641	2102	--	--	--	PP	Yes	--	12511
648	2125	--	--	--	PP	Yes	--	12512
656	2152	--	--	--	CP	Yes	--	12513

Target:	AA7017-T6			Date:	1-Apr-13				
Plate #:	495892-1E1			Test Site:	EF-108				
Lot#:	1E2								
Avg. Thickness:	1.512 "		38.398 mm						
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	30cal	APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	837 m/s		2745 ft/s						
High PP:	832 m/s		2729 ft/s						
V50:	833 m/s		2733 ft/s						
Std Dev:	5 m/s		16 ft/s			# shots:	4		
						Spread:	10 m/s		33 ft/s
ZMR:	0 m/s		0 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50		#	
837	2745	--	--	--	CP	Yes	--	11269	
785	2575	--	--	--	PP	No	--	11270	
809	2654	--	--	--	PP	No	--	11271	
817	2680	--	--	--	PP	No	--	11272	
827	2713	--	--	--	PP	Yes	--	11273	
837	2745	--	--	--	CP	Yes	--	11274	
832	2729	--	--	--	PP	Yes	--	11275	

Target:	AA7017-T6			Date:	4-Apr-13				
Plate #:	495871-1B2			Test Site:	EF-108				
Lot#:	1B2								
Avg. Thickness:	1.508 "		38.310 mm						
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	30cal APM2	Lot #:	TW18035						
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	833 m/s		2732 ft/s						
High PP:	836 m/s		2742 ft/s						
V50:	833 m/s		2731 ft/s			# shots:	4		
Std Dev:	4 m/s		13 ft/s			Spread:	9 m/s	30 ft/s	
ZMR:	3 m/s		10 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
834	2736	--	--	--	CP	Yes	--	11281	
820	2690	--	--	--	PP	No	--	11282	
827	2713	--	--	--	PP	Yes	--	11283	
836	2742	--	--	--	PP	Yes	--	11284	
833	2732	--	--	--	CP	Yes	--	11285	

Target:	AA7017-T7			Date:	7-Oct-10				
Plate #:	K889			Test Site:	EF-106				
Lot#:	K889								
Avg. Thickness:	1.533 "		38.932 mm						
Hardness:	124 HBN								
Obliquity:	0°								
Projectile:	30cal	APM2	Lot #:	TW18035					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	830 m/s		2722 ft/s						
High PP:	823 m/s		2699 ft/s						
V50:	827 m/s		2713 ft/s			# shots:	4		
Std Dev:	6 m/s		21 ft/s			Spread:	14 m/s	46 ft/s	
ZMR:	0 m/s		0 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50		#	
959	3146	--	--	--	CP	No	--	9906	
757	2483	--	--	--	PP	No	--	9907	
809	2654	--	--	--	PP	No	--	9908	
858	2814	--	--	--	CP	No	--	9909	
841	2758	--	--	--	CP	No	--	9910	
821	2693	--	--	--	PP	Yes	--	9911	
835	2739	--	--	--	CP	Yes	--	9912	
830	2722	--	--	--	CP	Yes	--	9913	
823	2699	--	--	--	PP	Yes	--	9914	

0.30-cal APM2 Kit

Target:	AA7017-T6			Date:	20-Mar-13				
Plate #:	495867-1A2			Test Site:	EF-106				
Projectile Lot#:	LC11J945S001								
Avg. Thickness:	0.507 "		12.878 mm						
Hardness:	137 HBN								
Obliquity:	30°								
Projectile:	30cal APM2	Kit							
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	485 m/s		1591 ft/s						
High PP:	487 m/s		1597 ft/s						
V50:	485 m/s		1591 ft/s			# shots:	6		
Std Dev:	9 m/s		30 ft/s			Spread:	27 m/s	89 ft/s	
ZMR:	2 m/s		7 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
488	1601	--	--	--	CP	Yes	--	12459	
458	1502	--	--	--	PP	No	--	12460	
478	1568	--	--	--	PP	Yes	--	12461	
469	1538	--	--	--	PP	No	--	12462	
487	1597	--	--	--	PP	Yes	--	12463	
500	1640	--	--	--	CP	Yes	--	12464	
473	1551	--	--	--	PP	Yes	--	12465	
485	1591	--	--	--	CP	Yes	--	12466	

Target:	AA7017-T6			Date:	19-Mar-13			
Plate #:	495867-3A1			Test Site:	EF-106			
Projectile Lot#:	LC11J945S001							
Avg. Thickness:	0.507 "		12.878 mm					
Hardness:	137 HBN							
Obliquity:	30°							
Projectile:	30cal APM2	Kit						
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Chrono							
Low CP:	484 m/s		1588 ft/s					
High PP:	476 m/s		1561 ft/s					
V50:	477 m/s		1563 ft/s			# shots:	6	
Std Dev:	11 m/s		35 ft/s			Spread:	24 m/s	79 ft/s
ZMR:	0 m/s		0 ft/s					
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
463	1519	--	--	--	PP	Yes	--	12449
492	1614	--	--	--	CP	No	--	12450
485	1591	--	--	--	CP	Yes	--	12451
476	1561	--	--	--	PP	Yes	--	12452
451	1479	--	--	--	PP	No	--	12453
427	1401	--	--	--	PP	No	--	12454
484	1588	--	--	--	CP	Yes	--	12455
487	1597	--	--	--	CP	Yes	--	12456
453	1486	--	--	--	PP	No	--	12457
464	1522	--	--	--	PP	Yes	--	12458

Target:	AA7017-T6			Date:	27-Mar-13				
Plate #:	495880-4E2			Test Site:	EF-106				
Projectile Lot#:	LC11J945S001								
Avg. Thickness:	1.005 "		25.527 mm						
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	30cal	APM2	Kit						
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	656 m/s		2152 ft/s						
High PP:	648 m/s		2125 ft/s						
V50:	653 m/s		2143 ft/s			# shots:	4		
Std Dev:	7 m/s		23 ft/s			Spread:	15 m/s	49 ft/s	
ZMR:	0 m/s		0 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
665	2181	--	--	--	CP	No	--	12497	
648	2125	--	--	--	PP	Yes	--	12498	
662	2171	--	--	--	CP	Yes	--	12499	
656	2152	--	--	--	CP	Yes	--	12500	
647	2122	--	--	--	PP	Yes	--	12501	

Target:	AA7017-T6		Date:	1-Apr-13					
Plate #:	495880-4B1		Test Site:	EF-106					
Projectile Lot#:	LC11J945S001								
Avg. Thickness:	1.003 "	25.476 mm							
Hardness:	131 HBN								
Obliquity:	0°								
Projectile:	30cal APM2								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	659 m/s	2162 ft/s							
High PP:	656 m/s	2152 ft/s							
V50:	660 m/s	2164 ft/s				# shots:	4		
Std Dev:	6 m/s	21 ft/s				Spread:	14 m/s	46 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
659	2162	--	--	--	CP	Yes	--	12502	
632	2073	--	--	--	PP	No	--	12503	
635	2083	--	--	--	PP	No	--	12504	
656	2152	--	--	--	PP	Yes	--	12505	
655	2148	--	--	--	PP	Yes	--	12506	
681	2234	--	--	--	PP	No	--	12507	
651	2135	--	--	--	CP	No	--	12508	
669	2194	--	--	--	CP	Yes	--	12509	

Target:	AA7017-T6			Date:	28-Mar-13						
Plate #:	495892-1E1			Test Site:	EF-108						
Projectile Lot#:	LC11J945S001										
Avg. Thickness:	1.512 "		38.398 mm								
Hardness:	137 HBN										
Obliquity:	0°										
Projectile:	30cal	APM2	Kit								
Setup:	AA7017-Air(6")-AA2024(0.020")										
Velocity Measurement:	Chrono										
Low CP:	860 m/s		2821 ft/s								
High PP:	852 m/s		2795 ft/s								
V50:	857 m/s		2811 ft/s			# shots:	4				
Std Dev:	7 m/s		24 ft/s			Spread:	16 m/s		52 ft/s		
ZMR:	0 m/s		0 ft/s								
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #			
843	2765	--	--	--	PP	No	--	11264			
866	2840	--	--	--	CP	Yes	--	11265			
860	2821	--	--	--	CP	Yes	--	11266			
852	2795	--	--	--	PP	Yes	--	11267			
850	2788	--	--	--	PP	Yes	--	11268			

Target:	AA7017-T6			Date:	3-Apr-13				
Plate #:	495892-1B2			Test Site:	EF-108				
Projectile Lot#:	LC11J945S001								
Avg. Thickness:	1.508 "		38.310 mm						
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	30cal	APM2	M2 Kit						
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Chrono								
Low CP:	845 m/s		2772 ft/s						
High PP:	850 m/s		2788 ft/s						
V50:	847 m/s		2779 ft/s			# shots:	4		
Std Dev:	7 m/s		22 ft/s			Spread:	16 m/s	52 ft/s	
ZMR:	5 m/s		16 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
857	2811	--	--	--	CP	No	--	11276	
839	2752	--	--	--	PP	Yes	--	11277	
850	2788	--	--	--	PP	Yes	--	11278	
855	2804	--	--	--	CP	Yes	--	11279	
845	2772	--	--	--	CP	Yes	--	11280	

0.50-cal APM2

Target:	AA7017-T6		Date:	11-Mar-13					
Plate #:	495892		Test Site:	EF-110G					
Lot#:	1E1								
Avg. Thickness:	1.511 "	38.379 mm							
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	0.50cal APM2				16.68083				
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	630 m/s	2066 ft/s							
High PP:	622 m/s	2040 ft/s							
V50:	626 m/s	2052 ft/s			# shots:	4			
Std Dev:	6 m/s	19 ft/s			Spread:	12 m/s	39 ft/s		
ZMR:	0 m/s	0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
615	2017	--	--	0.25	PP	No	--	14263	
622	2040	--	--	0.50	PP	Yes	--	14264	
619	2030	--	--	0.00	PP	Yes	--	14265	
630	2066	--	--	0.00	CP	Yes	--	14266	
631	2070	--	--	0.75	CP	Yes	--	14267	

Target:	AA7017-T7			Date:	28-Jul-10				
Plate #:	K889-T7651			Test Site:	EF-108				
Lot#:	T7651								
Avg. Thickness:	1.532 "		38.913 mm						
Hardness:	124 HBN								
Obliquity:	0°								
Projectile:	0.50cal	APM2	Lot #:	RA5735					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	624 m/s		2047 ft/s						
High PP:	628 m/s		2060 ft/s						
V50:	625 m/s		2049 ft/s			# shots:	6		
Std Dev:	8 m/s		25 ft/s			Spread:	20 m/s	66 ft/s	
ZMR:	4 m/s		13 ft/s						
	Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
	633	2076	--	--	--	CP	Yes	--	9250
	570	1870	--	--	--	PP	No	--	9251
	624	2047	--	--	--	CP	Yes	--	9252
	607	1991	--	--	--	PP	No	--	9253
	628	2060	--	--	--	PP	Yes	--	9254
	631	2070	--	--	--	CP	Yes	--	9255
	629	2063	--	--	--	CP	No	Disregard	9256
	613	2011	--	--	--	PP	Yes	--	9257
	619	2030	--	--	--	PP	Yes	--	9258

V50 Summary Sheet

Date: 3/27/2013

Engineer: Tyrone Jones

Technicians: Koch/Walter

Contract Number

Test Facility:	EF110 G
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Target Description:	AA 7017-T6	Plate ID #495905	Heat ID #2G2
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Penetrator: .50 CAL AP M2

Weapon:	AB21	.50 CAL
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Requirements (ft/sec):

Temp/Humidity	F/	%
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[illegible]

BHN	131					Thickness	2.011
Low CP	f/s 2389	m/s 728			Vel Spread f/s 36		
High Partial	f/s 2370	m/s 722			ZMR f/s 0		
V50	f/s 2381	m/s 725	* = Shots used for V50				Avg 2.011
Std Dev	f/s 17	m/s 5					

Target:	AA7017-T7			Date:	26-Jul-10				
Plate #:	K889-T7651			Test Site:	EF-108				
Lot#:	T7651								
Avg. Thickness:	2.063 "		52.388 mm						
Hardness:	128 HBN								
Obliquity:	0°								
Projectile:	0.50cal	APM2	Lot #:	RA5735					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray					18.973666			
Low CP:	734 m/s		2408 ft/s						
High PP:	729 m/s		2391 ft/s						
V50:	731 m/s		2399 ft/s			# shots:	4		
Std Dev:	6 m/s		20 ft/s			Spread:	14 m/s	46 ft/s	
ZMR:	0 m/s		0 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
734	2408	--	--	0.56	CP	Yes	--	9243	
715	2345	--	--	0.56	PP	No	--	9244	
724	2375	--	--	0.56	PP	Yes	--	9245	
738	2421	--	--	0.71	CP	Yes	--	9246	
714	2342	--	--	1.03	PP	No	--	9247	
716	2348	--	--	1.12	PP	No	--	9248	
729	2391	--	--	0.35	PP	Yes	--	9249	

V50 Summary Sheet

Date: 3/28/2013

Engineer: Tyrone Jones

Technicians: Koch/Walter

Contract Number

Test Facility:	EF110 G
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Target Description:	AA 7017-T6	Plate ID #495930	Heat ID #2H1
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Penetrator: .50 CAL AP M2

Weapon:	AB21	.50 CAL
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Requirements (ft/sec):

Temp/Humidity	F/
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%

[illegible]

BHN	134					Thickness	2.519
Low CP	t/s 2776	m/s 846			Vel Spread t/s 61 **		
High Partial	t/s 2730	m/s 832			ZMR t/s 0		
V50	t/s 2751	m/s 839	* = Shots used for V50				Avg 2.519
Std Dev	t/s 31	m/s 9					

** = Calculated in m/s which resulted in 18m/s requirement

V50 Summary Sheet

Date: 4/1/2013

Engineer: Tyrone Jones

Technicians: Koch/Walter

Contract Number

Test Facility:	EF110 G
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Target Description:	AA 7017-T6	Plate ID #495930	Heat ID #2K1
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Penetrator: .50 CAL AP M2

Weapon:	AB21	.50 CAL
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Requirements (ft/sec):

Temp/Humidity	F/	%
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[illegible]

BHN	134					Thickness	2.519
Low CP	f/s 2734	m/s 833			Vel Spread f/s 56		
High Partial	f/s 2710	m/s 826			ZMR f/s 0		
V50	f/s 2727	m/s 831	* = Shots used for V50				Avg 2.519
Std Dev	f/s 26	m/s 8					

V50 Summary Sheet

Date: 4/2/2013

Engineer: Tyrone Jones

Technicians: Koch/Walter

Contract Number

Test Facility:	EF110 G
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Target Description:	AA 7017-T6	Plate ID #495935	Heat ID #1D2
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Penetrator: .50 CAL AP M2

Weapon:	AB21	.50 CAL
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Requirements (ft/sec):

Temp/Humidity	F/	%
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[illegible]

BHN	134					Thickness	3.019
Low CP	f/s 3065	m/s 934			Vel Spread f/s 42		
High Partial	f/s 3051	m/s 930			ZMR f/s 0		
V50	f/s 3053	m/s 931	* = Shots used for V50				
Std Dev	f/s 19	m/s 6				Avg	3.019

Target:	AA7017-T7		Date:	23-Jul-10					
Plate #:	K889-T7651		Test Site:	EF-108					
Lot#:	T7651								
Avg. Thickness:	2.947 "	74.860 mm							
Hardness:	128 HBN								
Obliquity:	0°								
Projectile:	0.50cal	APM2	Lot #:	RA5735					
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	902 m/s	2959 ft/s							
High PP:	895 m/s	2936 ft/s							
V50:	899 m/s	2947 ft/s		# shots: 4					
Std Dev:	5 m/s	17 ft/s		Spread: 11 m/s 36 ft/s					
ZMR:	0 m/s	0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
895	2936	--	--	0.25	PP	Yes	--	9238	
904	2965	--	--	0.5	CP	Yes	--	9239	
885	2903	--	--	1.03	PP	No	--	9240	
902	2959	--	--	0.5	CP	Yes	--	9241	
893	2929	--	--	--	PP	Yes	--	9242	

14.5 mm BS41

Target:	AA7017-T6		Date:	20-Feb-13					
Plate #:	495935-1D1		Test Site:	EF-108					
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	3.018 "	76.651 mm							
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AL 2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	870 m/s	2854 ft/s							
High PP:	858 m/s	2814 ft/s							
V50:	864 m/s	2832 ft/s				# shots:	4		
Std Dev:	8 m/s	25 ft/s				Spread:	14 m/s	46 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)	for V50			
778	2552	--	--	0.56	PP	No	--	11165	
848	2781	--	--	0.00	PP	No	--	11166	
898	2945	--	--	1.46	CP	No	--	11167	
870	2854	--	--	1.25	CP	Yes	--	11168	
858	2814	--	--	1.46	PP	Yes	--	11169	
856	2808	--	--	0.50	PP	Yes	--	11170	
870	2854	--	--	0.35	CP	Yes	--	11171	

Target:	AA7017-T6			Date:	25-Feb-13				
Plate #:	495935-1D2			Test Site:	EF-108				
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	3.019 "			76.676 mm					
Hardness:	134 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AL 2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	858 m/s		2814 ft/s						
High PP:	859 m/s		2818 ft/s						
V50:	859 m/s		2816 ft/s			# shots:	4		
Std Dev:	6 m/s		20 ft/s			Spread:	15 m/s	49 ft/s	
ZMR:	1 m/s		3 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
872	2860	--	--	1.41	CP	No	--	11172	
859	2818	--	--	1.46	PP	Yes	--	11173	
858	2814	--	--	1.58	CP	Yes	--	11174	
866	2840	--	--	1.03	CP	Yes	--	11175	
868	2847	--	--	1.77	CP	No	--	11176	
851	2791	--	--	1.82	PP	Yes	--	11177	

Target:	AA7017-T7		Date:	22-Feb-13					
Plate #:	K889-T7651		Test Site:	EF-108					
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	2.947 "	74.860 mm							
Hardness:	128 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	836 m/s	2742 ft/s							
High PP:	837 m/s	2745 ft/s							
V50:	837 m/s	2745 ft/s			# shots:	4			
Std Dev:	5 m/s	18 ft/s			Spread:	13 m/s	43 ft/s		
ZMR:	1 m/s	3 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
813	2667	--	--	0.56	PP	No	--	9377	
870	2854	--	--	0.25	CP	No	--	9378	
837	2745	--	--	0.90	PP	Yes	--	9379	
836	2742	--	--	0.56	CP	Yes	--	9380	
844	2768	--	--	0.79	CP	Yes	--	9381	
831	2726	--	--	0.35	PP	Yes	--	9382	

Target:	AA7017-T6		Date:	26-Feb-13					
Plate #:	495953-1E1		Test Site:	EF-108					
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	3.523 "	89.472 mm							
Hardness:	140 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AL 2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	951 m/s	3119 ft/s							
High PP:	944 m/s	3096 ft/s							
V50:	948 m/s	3108 ft/s				# shots:	4		
Std Dev:	8 m/s	25 ft/s				Spread:	17 m/s	56 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
926	3037	--	--	1.06	PP	No	--	11178	
951	3119	--	--	1.52	CP	Yes	--	11179	
962	3155	--	--	0.71	CP	No	--	11180	
956	3136	--	--	0.79	CP	Yes	--	11181	
957	3139	--	--	3.81	CP	No	--	11182	
924	3031	--	--	1.00	PP	No	--	11183	
939	3080	--	--	1.82	PP	Yes	--	11184	
926	3037	--	--	0.56	PP	No	--	11185	
944	3096	--	--	0.25	PP	Yes	--	11186	

Target:	AA7017-T6		Date:	27-Feb-13					
Plate #:	495953-1E2		Test Site:	EF-108					
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	3.524 "	89.516 mm							
Hardness:	134 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	938 m/s	3077 ft/s							
High PP:	941 m/s	3086 ft/s							
V50:	941 m/s	3087 ft/s			# shots:	6			
Std Dev:	10 m/s	33 ft/s			Spread:	24 m/s	79 ft/s		
ZMR:	3 m/s	10 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
932	3057	--	--	0.50	PP	Yes	--	11187	
941	3086	--	--	1.03	PP	Yes	--	11188	
938	3077	--	--	0.71	CP	Yes	--	11189	
930	3050	--	--	0.75	PP	Yes	--	11190	
952	3123	--	--	1.00	CP	Yes	--	11191	
954	3129	--	--	0.71	CP	Yes	--	11192	

Target:	AA7017-T6			Date:	4-Mar-13			
Plate #:	495959-1G1			Test Site:	EF-108			
Projectile Lot#:	ARL-02-C-0105							
Avg. Thickness:	4.042 "	102.654	mm					
Hardness:	131	HBN						
Obliquity:	0°							
Projectile:	14.5mm	BS41						
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	0 m/s	0	ft/s					
High PP:	1015 m/s	3329	ft/s					
V50:	0 m/s	0	ft/s	# shots:	1			
Std Dev:	0 m/s	0	ft/s	Spread:	0 m/s	0	ft/s	
ZMR:	0 m/s	0	ft/s					
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)			
986	3234	--	--	0.79	PP	No	--	11193
995	3264	--	--	1.03	PP	No	--	11194
1015	3329	--	--	2.06	PP	No	--	11195
*Halted testing - maximum safe load for gun								

Target:	AA7017-T6		Date:	4-Mar-13					
Plate #:	495959-1G2		Test Site:	EF-108					
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	4.034 "	102.46 mm							
Hardness:	143 HBN								
Obliquity:	0°								
Projectile:	14.5mm BS41								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	0 m/s	0 ft/s							
High PP:	1014 m/s	3326 ft/s							
V50:	0 m/s	0 ft/s				# shots:	1		
Std Dev:	0 m/s	0 ft/s				Spread:	0 m/s	0 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
1019	3342	--	--	8.62	PP	No	High gamma	11196	
995	3264	--	--	2.00	PP	No	--	11197	
1014	3326	--	--	1.52	PP	Yes	--	11198	
		*Halted testing - maximum safe load for gun							

Target:	AA7017-T7			Date:	23-Sep-10				
Plate #:	K889-T7651			Test Site:	EF-108				
Projectile Lot#:	ARL-02-C-0105								
Avg. Thickness:	3.898 "		99.016 mm						
Hardness:	121	HBN							
Obliquity:	0°								
Projectile:	14.5mm	BS41							
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	983 m/s		3224 ft/s						
High PP:	984 m/s		3228 ft/s						
V50:	984 m/s		3226 ft/s			# shots:	4		
Std Dev:	5 m/s		15 ft/s			Spread:	11 m/s	36 ft/s	
ZMR:	1 m/s		3 ft/s						
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
950	3116	--	--	0.58	PP	No	--	9383	
1002	3287	--	--	0.71	CP	No	--	9384	
984	3228	--	--	0.35	PP	Yes	--	9385	
1000	3280	--	--	0.25	CP	No	--	9386	
989	3244	--	--	0.35	CP	Yes	--	9387	
983	3224	--	--	0.56	CP	Yes	--	9388	
993	3257	--	--	0.00	CP	No	--	9389	
978	3208	--	--	0.25	PP	Yes	--	9390	

0.50-cal FSP

Target:	AA7017-T6		Date:	21-Feb-13					
Plate #:	495871-1G2		Test Site:	EF-110G					
Lot#:	495871								
Avg. Thickness:	0.7595 "	19.291 mm							
Hardness:	134 HBN								
Obliquity:	0°								
Projectile:	0.50cal	FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	658 m/s	2158 ft/s							
High PP:	656 m/s	2152 ft/s							
V50:	660 m/s	2164 ft/s				# shots:	4		
Std Dev:	8 m/s	25 ft/s				Spread:	17 m/s	56 ft/s	
ZMR:	0 m/s	0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
765	2509	--	--	--	CP	No	No x-rays, Velocity measured by hand	14211	
676	2217	-0.75	-0.50	0.90	CP	No	--	14212	
648	2125	-0.50	0.50	0.71	PP	No	--	14213	
593	1945	--	--	--	CP	No	No x-rays, Velocity measured by hand	14214	
658	2158	0.50	0.75	0.90	CP	Yes	--	14215	
656	2152	-0.25	0.50	0.56	PP	Yes	--	14216	
654	2145	0.00	1.00	1.00	PP	Yes	--	14217	
671	2201	-0.50	0.00	0.50	CP	Yes	--	14218	

Target:	AA7017-T6			Date:	21-Feb-13				
Plate #:	495871-5G1			Test Site:	EF-110G				
Lot#:	495871								
Avg. Thickness:	0.760	"	19.304	mm					
Hardness:	137 HBN								
Obliquity:	0°								
Projectile:	0.50cal	FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	622	m/s	2040	ft/s					
High PP:	623	m/s	2043	ft/s					
V50:	625	m/s	2050	ft/s	# shots:	4			
Std Dev.	5	m/s	15	ft/s	Spread:	10	m/s	33	ft/s
ZMR:	1	m/s	3	ft/s					
Striking	Striking	Pitch	Yaw	Gamma	Result	Used	Comments	Shot	
Velocity	Velocity					for V50		#	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
646	2119	0.50	1.00	1.12	CP	No	--	14219	
654	2145	0.00	1.50	1.50	CP	No	--	14220	
642	2106	-0.50	0.50	0.71	CP	No	--	14221	
632	2073	0.00	0.50	0.50	CP	Yes	--	14222	
612	2007	0.00	0.50	0.50	PP	No	--	14223	
623	2043	0.25	0.25	0.35	CP	Yes	--	14224	
623	2043	0.25	-0.25	0.35	PP	Yes	--	14225	
622	2040	0.50	0.50	0.71	PP	Yes	--	14226	

Target:	AA7017-T7			Date:	29-Oct-10						
Plate #:	K889-T7651			Test Site:	EF-108						
Lot#:	T7651										
Avg. Thickness:	0.783 "			19.888 mm							
Hardness:	128 HBN										
Obliquity:	0°										
Projectile:	0.50cal FSP										
Setup:	AA7017-Air(6")-AA2024(0.020")										
Velocity Measurement:	Xray										
Low CP:	655 m/s			2148 ft/s							
High PP:	645 m/s			2116 ft/s							
V50:	650 m/s			2130 ft/s		# shots:	4				
Std Dev:	8 m/s			25 ft/s		Spread:	16 m/s			52 ft/s	
ZMR:	0 m/s			0 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #			
607	1991	--	--	0.58	PP	No	--	9464			
657	2155	--	--	0.71	CP	Yes	--	9469			
634	2080	--	--	0.35	PP	No	--	9470			
655	2148	--	--	0.25	CP	Yes	--	9471			
641	2102	--	--	0.35	PP	Yes	--	9472			
645	2116	--	--	0.56	PP	Yes	--	9473			

Target:	AA7017-T6		Date:	24-Feb-13					
Plate #:	495880-4E2		Test Site:	EF-110G					
Lot#:	495880								
Avg. Thickness:	1.004 "	25.502 mm							
Hardness:	126 HBN								
Obliquity:	0°								
Projectile:	0.50cal	FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	1055 m/s	3460 ft/s							
High PP:	1042 m/s	3418 ft/s							
V50:	1049 m/s	3441 ft/s			# shots:	4			
Std Dev:	8 m/s	27 ft/s			Spread:	15 m/s	49 ft/s		
ZMR:	0 m/s	0 ft/s							
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #	
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)				
948	3109	--	--	0.71	PP	No	No x-rays, Velocity measured by hand	14195	
956	3136	--	--	0.35	PP	No	--	14196	
972	3188	--	--	0.56	PP	No	--	14197	
998	3273	--	--	0.75	PP	No	No x-rays, Velocity measured by hand	14198	
1038	3405	--	--	0.25	PP	No	--	14199	
1055	3460	--	--	10.28	CP	Yes	High gamma, bad yaw used because it is a CP	14200	
1042	3418	--	--	0.90	PP	Yes	--	14201	
1067	3500	--	--	0.79	CP	No	--	14202	
1105	3624	--	--	0.90	CP	No		14203	
1057	3467	--	--	0.75	CP	Yes		14204	
1223	4011	--	--	--	CP	No	No x-rays, Velocity measured by hand	14205	
946	3103	--	--	0.35	PP	No	--	14206	
1042	3418	--	--	1.25	PP	Yes	--	14207	

Target:	AA7017-T6		Date:	26-Feb-13				
Plate #:	495880-4B1		Test Site:	EF-110G				
Lot#:	495880							
Avg. Thickness:	1.003 "	25.476 mm						
Hardness:	131 HBN							
Obliquity:	0°							
Projectile:	0.50cal FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	1100 m/s	3608 ft/s						
High PP:	1086 m/s	3562 ft/s						
V50:	1093 m/s	3583 ft/s			# shots:	4		
Std Dev:	9 m/s	31 ft/s			Spread:	18 m/s	59 ft/s	
ZMR:	0 m/s	0 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
1100	3608	--	--	0.25	CP	Yes	--	14227
1004	3293	--	--	1.27	PP	No	--	14228
1038	3405	--	--	0.50	PP	No	--	14229
1057	3467	--	--	0.50	PP	No	--	14230
1105	3624	--	--	0.00	CP	No	--	14231
1036	3398	--	--	0.79	PP	No	--	14232
1058	3470	--	--	0.50	PP	No	--	14233
1083	3552	--	--	1.06	PP	Yes	--	14234
1086	3562	--	--	0.25	PP	Yes	--	14235
1101	3611	--	--	0.25	CP	Yes	--	14236

20 mm FSP

Target:	AA7017-T7			Date:	5-Aug-10			
Plate #:	K889 T7651, 469280A2			Test Site:	EF-108			
Lot#:	469280A2							
Avg. Thickness:	0.786 "	19.952 mm						
Hardness:	128 HBN							
Obliquity:	0°							
Projectile:	20mm FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	330 m/s	1082 ft/s						
High PP:	362 m/s	1187 ft/s						
V50:	346 m/s	1135 ft/s			# shots:	10		
Std Dev:	21 m/s	69 ft/s			Spread:	50 m/s	164 ft/s	
ZMR:	32 m/s	105 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
300	984	--	--	1.03	PP	No	--	9267
316	1036	--	--	0.50	PP	No	--	9268
354	1161	--	--	1.75	CP	Yes	--	9269
330	1082	--	--	2.76	CP	Yes	--	9270
316	1036	--	--	2.93	PP	Yes	--	9271
318	1043	--	--	2.15	PP	Yes	--	9272
325	1066	--	--	1.03	PP	Yes	--	9273
362	1187	--	--	2.50	PP	Yes	--	9274
380	1246	--	--	2.51	CP	No	--	9275
365	1197	--	--	0.35	CP	Yes	--	9276
360	1181	--	--	1.82	PP	Yes	--	9277
363	1191	--	--	0.25	CP	Yes	--	9278
366	1200	--	--	0.90	CP	Yes	--	9279

Target:	AA7017-T6		Date:	31-Jan-13					
Plate #:	495880-4B1		Test Site:	EF-110E					
Lot#:	495880								
Avg. Thickness:	1.003 "	25.476 mm							
Hardness:	131 HBN								
Obliquity:	0°								
Projectile:	20mm FSP								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	453 m/s	1486 ft/s							
High PP:	458 m/s	1502 ft/s							
V50:	462 m/s	1517 ft/s				# shots:	4		
Std Dev:	9 m/s	31 ft/s				Spread:	20 m/s	66 ft/s	
ZMR:	5 m/s	16 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
444	1456	1.00	-1.00	1.41	PP	No	--	1916	
367	1204	0.00	1.00	1.00	PP	No	--	1917	
408	1338	-0.25	0.25	0.35	PP	No	--	1918	
421	1381	0.25	-0.25	0.35	PP	No	--	1919	
440	1443	0.00	0.25	0.25	PP	No	--	1920	
458	1502	-0.50	-0.25	0.56	PP	Yes	--	1921	
487	1597	-0.50	-0.25	0.56	CP	No	--	1922	
473	1551	-0.25	0.00	0.25	CP	No	--	1923	
472	1548	0.25	-0.50	0.56	CP	Yes	--	1924	
453	1486	-0.50	0.00	0.5	CP	Yes	--	1925	
456	1496	-0.25	0.25	0.35	PP	Yes	--	1926	

Target:	AA7017-T6		Date:	4-Feb-13					
Plate #:	495880-4E2		Test Site:	EF-110E					
Lot#:	495880								
Avg. Thickness:	1.004 "	25.502 mm							
Hardness:	126 HBN								
Obliquity:	0°								
Projectile:	20mm FSP								
Setup:	AA7017-Air(6")-AA2024(0.020")								
Velocity Measurement:	Xray								
Low CP:	462 m/s	1515 ft/s							
High PP:	463 m/s	1519 ft/s							
V50:	463 m/s	1519 ft/s				# shots:	4		
Std Dev:	5 m/s	16 ft/s				Spread:	12 m/s	39 ft/s	
ZMR:	1 m/s	3 ft/s							
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #	
462	1515	0.25	-0.25	0.35	CP	Yes	--	1927	
447	1466	0.25	0.75	0.79	PP	No	--	1928	
458	1502	0.00	0.25	0.25	PP	Yes	--	1929	
463	1519	0.25	-0.25	0.35	PP	Yes	--	1930	
470	1542	0.00	0.25	0.56	CP	Yes	--	1931	

Target:	AA7017-T6			Date:	5-Feb-13			
Plate #:	495892-1E1			Test Site:	EF-110E			
Lot#:	495892							
Avg. Thickness:	1.511	"	38.379	mm				
Hardness:	137	HBN						
Obliquity:	0°							
Projectile:	20mm	FSP						
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	902	m/s	2959	ft/s				
High PP:	900	m/s	2952	ft/s				
V50:	903	m/s	2962	ft/s		# shots:	4	
Std Dev:	7	m/s	23	ft/s		Spread:	16	m/s
								52
ZMR:	0	m/s	0	ft/s				
Striking Velocity	Striking Velocity	Pitch	Yaw	Gamma	Result	Used for V50	Comments	Shot #
(m/s)	(ft/s)	(deg)	(deg)	(deg)	(PP/CP)			
821	2693	-1.50	-0.50	1.58	PP	No	--	1932
862	2827	0.00	-0.50	0.50	PP	No	--	1933
900	2952	0.25	-0.25	0.35	PP	Yes	--	1934
902	2959	-0.25	0.25	0.35	CP	Yes	--	1935
913	2995	0.25	-0.75	0.79	CP	Yes	--	1936
897	2942	-0.25	-0.25	0.35	PP	Yes	--	1937

Target:	AA7017-T6			Date:	12-Feb-13			
Plate #:	495892-1B2			Test Site:	EF-110E			
Lot#:	1B2							
Avg. Thickness:	1.508 "		38.303 mm					
Hardness:	137 HBN							
Obliquity:	0°							
Projectile:	20mm FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	872 m/s		2860 ft/s					
High PP:	881 m/s		2890 ft/s					
V50:	877 m/s		2877 ft/s			# shots:	4	
Std Dev:	5 m/s		15 ft/s			Spread:	9 m/s	30 ft/s
ZMR:	9 m/s		30 ft/s					
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
910	2985	0.25	0.25	0.35	CP	No	--	1939
906	2972	0.25	1.00	1.03	CP	No	--	1940
916	3004	-0.75	0.00	0.75	CP	No	--	1941
912	2991	0.00	-0.50	0.50	CP	No	--	1942
906	2972	-0.50	0.25	0.56	CP	No	--	1943
888	2913	0.00	-0.25	0.25	CP	No	--	1944
848	2781	0.25	0.00	0.25	PP	No		1945
842	2762	0.25	0.00	0.25	PP	No		1946
858	2814	-0.50	-0.25	0.56	PP	No		1947
872	2860	0.00	0.00	0.00	CP	Yes		1948
881	2890	0.00	-0.50	0.50	CP	Yes		1949
874	2867	-0.25	-0.50	0.56	PP	Yes		1950
881	2890	-1.25	0.25	1.25	PP	Yes		1951

Target:	AA7017-T7			Date:	5-Aug-10			
Plate #:	46950640-K889 & T7651			Test Site:	EF-108			
Lot#:	K889 & T7651							
Avg. Thickness:	1.533 "	38.932 mm						
Hardness:	124 HBN							
Obliquity:	0°							
Projectile:	20mm FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	868 m/s	2847 ft/s						
High PP:	914 m/s	2998 ft/s						
V50:	903 m/s	2962 ft/s			# shots:	10		
Std Dev:	19 m/s	62 ft/s			Spread:	57 m/s	187 ft/s	
ZMR:	46 m/s	151 ft/s						
Striking Velocity (m/s)	Striking Velocity (ft/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
868	2847	--	--	1.82	CP	Yes	--	9280
839	2752	--	--	1.58	PP	No	--	9281
852	2795	--	--	2.02	PP	No	--	9282
860	2821	--	--	2.85	PP	No	--	9283
863	2831	--	--	3.25	PP	No	--	9284
874	2867	--	--	3.04	PP	No	--	9285
879	2883	--	--	2.50	PP	Yes	--	9286
877	2877	--	--	2.80	PP	No	--	9287
895	2936	--	--	3.04	PP	Yes	--	9288
891	2922	--	--	1.06	PP	Yes	--	9289
910	2985	--	--	0.35	PP	Yes	--	9290
925	3034	--	--	2.80	CP	Yes	--	9291
915	3001	--	--	0.35	CP	Yes	--	9292
918	3011	--	--	0.25	CP	Yes	--	9293
916	3004	--	--	2.50	CP	Yes	--	9294
914	2998	--	--	2.00	PP	Yes	--	9295

Target:	AA7017-T6			Date:	18-Jun-13			
Plate #:	495905-2F1			Test Site:	EF-110G			
Projectile Lot#:								
Avg. Thickness	2.013 "	51.130 mm						
Hardness:	131 HBN							
Obliquity:	0°							
Projectile:	20mm FSP							
Setup:	AA7017-Air(6")-AA2024(0.020")							
Velocity Measurement:	Xray							
Low CP:	1299 m/s	4263 ft/s						
High PP:	1297 m/s	4255 ft/s						
V50:	1301 m/s	4269 ft/s	# shots:	4				
Std Dev:	8 m/s	27 ft/s	Spread:	18 m/s	60 ft/s			
ZMR:	0 m/s	0 ft/s						
Striking Velocity (ft/s)	Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Gamma (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
4625	1410	--	--	0.56	CP	No	--	14451
4350	1326	--	--	1.00	CP	No	--	14452
4058	1237	--	--	0.56	CP	No	*DISREGARD Shot for V50; Witness broke from debris flying thru crack at back of target	14453
4058	1237	--	--	1.50	PP	No	--	14454
4043	1232	--	--	0.00	PP	No	--	14455
4105	1251	--	--	1.75	PP	No	--	14456
4131	1259	--	--	0.25	PP	No	--	14457
4263	1299	--	--	2.30	CP	Yes	--	14458
4203	1281	--	--	0.75	PP	No	--	14459
4248	1295	--	--	0.56	PP	Yes	--	14460
4255	1297	--	--	2.51	PP	Yes	--	14461
4308	1313	--	--	0.50	CP	Yes	--	14462

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List of Symbols, Abbreviations, and Acronyms

AA	aluminum alloy
AP	armor-piercing
CP	complete penetration
FSP	fragment-simulating projectile
ID	identification
IR	infrared
PP	partial penetration

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